bed, will enable him to cut the smooth end without altering the scale a third time.

If the Society should think these additional remarks worthy of consideration, and likely to be useful to the public, I shall feel gratified in having performed a duty due to them who considered my former communication worthy of their notice, and who rewarded the improvement with their Large Silver Medal.

I am, Sir, &c. &c.

MICHAEL STAUNTON.

A. AIKIN, Esq.
Secretary, &c. &c.

No. XVI.

GRAPHIC TELESCOPE.

The Thanks of the Society were presented to Mr. C. VARLEY, 1 Charles Street, Clarendon Square, for the following description of his Graphic Telescope and Microscope.

SIR,

THE graphic telescope for which I some years since obtained a patent, received, during the existence of, and subsequently to, the expiration of the patent, so many modifications, as to be in some respects a new instrument.

Though it has been noticed in several publications, no complete or intelligible description of it has yet been

published; and if the Society should deem it, with its improvements, together with the adaptation which I have since effected to the delineation of microscopic objects, worthy of insertion in their volume, I shall be happy to furnish the requisite drawings and description.

I am, Sir, &c. &c.

A. Aikin, Esq. C. Varley.
Secretary, &c. &c.

Mr. Cornelius Varley's description of his Graphic Telescope and Microscope, by which the most distant views, or the nearest objects, may be traced of any required size.

In order to make this instrument better understood, I will first shew its difference from the previously known and really excellent instrument, the camera obscura; then explain its mode of action; thirdly, its construction; and, fourthly, the various purposes to which it may be applied.

Most persons know that the camera obscura is formed with a plain mirror and a lens, which projects a picture on paper; but to render that picture visible, the whole space from the lens to the paper requires to be inclosed in a dark chamber, so as totally to exclude all other light; hence its name. Images of any size, and of great brilliancy, may be formed by this instrument, if we use a large plane metallic speculum, and lenses of sufficiently long focus, and so well constructed as to bear, and have, the largest possible aperture. The distance of the lens from its focus is the perspective distance of the picture which it produces, or, in other words, is the distance of

the station-point from which that picture should be viewed; because it then appears exactly of the same size as the original objects.

A camera obscura may be constructed to give images of all the most useful sizes at a moderate price; yet the expense and trouble of moving it from place to place, and its high and broad surface enabling the wind to interfere with its required steadiness, are objections to its general adoption.

The image given by a telescope is subject only to few of these objections. The size of the image does not depend on the focal distance of the object-glass, but on the proportion between its focal distance and that of the eye-piece; and the brightness of that image depends, within certain limits, on the diameter of the object-glass. Therefore, a small telescope will give an image as big as a large camera obscura; but it will not project that image on paper, and, as we usually look into the telescope to see the image within the tube, it cannot be transferred to paper by tracing. In my graphic telescope I have contrived to place the image apparently outside of the tube; and, although not actually projected on any surface, yet the observer receives the rays from the telescope into his eye in such a manner that they may be made to appear to come from a sheet of paper suitably placed for the purpose; therefore, this image may be traced on the paper. The size of the image may be varied very considerably without altering the size of the apparatus: sketches, therefore, on a very large or very small scale may be made by the same instrument; and as it never requires any additional height, or any shade to exclude daylight from the image, it offers no broad surface to be affected by the wind, and thus be rendered unsteady.

The image which we are enabled to trace with my instrument is a telescopic one ; and I will now shew how that image is produced. Fig. 1, Plate IV. is a diagram of one of the smallest graphic telescopes, half the real size, containing all the optical portion freed from the surrounding tubes. Let the arrow *a b* represent an object to be drawn; in this instance it is a near one, the instrument being used as a microscope: *c* is a flat speculum placed at an angle of 45° with the axis of the telescope ; it receives the various pencils of rays which diverge from every point of the object (to avoid confusion, only the middle and two extreme ones are shewn), and reflects them to the double convex object-glass *d:* this is sometimes made with two such lenses; but the larger instruments have achromatic object-glasses; in all cases, the thinner the object-glass is the better: the object-glass refracts the various rays about its focus, so as to form the curved image *a′ b′ :* here these rays will cross and diverge, and are to pass through the eye-lens *e*, which will render them so nearly parallel as to give distinct vision of the image, the eye-glass being placed so that its focus just meets that of the object-glass. But though the central pencils of rays would proceed to the eye-lens *e*, it will be seen that the outer pencils would pass on in the direction *f f* beyond the diameter of the lens *e*, and be lost : to prevent this, another lens, or two equivalent ones *g g*, must be placed on the image *a′b′*, where the rays cross. A lens so placed does not affect the crossing of the rays, but it deflects each pencil in mass towards the axis, from the course *ff* into the course *h h*, where they will arrive at the eye-lens *e*, and by it be refracted at a still quicker rate towards the axis, and rendered nearly parallel. These pencils are all of the same size, and meet together in the axis, where,

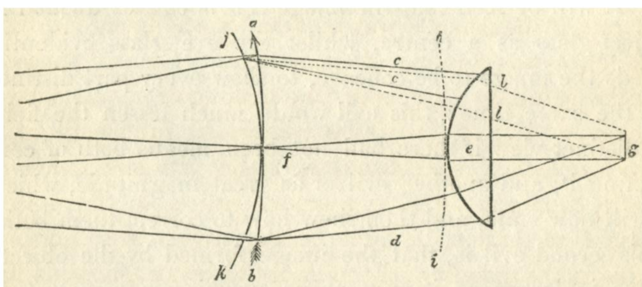
if the eye is placed, it can receive them all, and will then see the whole area of the lens filled with the image: this area is called the field of view; and because the lens *g* greatly increases the diameter of that area, it is called the field-glass. The pencils all meeting together, a cap with an eye-hole of the size of one pencil is usually put there, that being large enough for them all to pass through to the eye.

It will be seen that the image *a′ b′* is convex about the object-glass as a centre, whilst the eye-glass evidently needs the image to be concave, to shew every part distinct at the same time: this evil would much lessen the field of distinct view if there had not been means both of correcting it, and another evil of as great magnitude, which I will now state, and then shew how to correct them both. This second evil is, that the image formed by the object-glass is larger as it approaches the circumference than at the centre, a square being shewn like a pin-cushion; so that, instead of right lines, the four sides will be curved inwards: and the eye-glass, also, has the same fault, magnifying the circumference more than the centre, and thus increasing the evil.

If the field-glass *g* is removed from the neutral point, —namely, that where the image is formed, or where the rays cross, and the two focuses meet,—and is placed nearer to the eye-lens, it will combine with it, and increase the magnifying power; but, if it is put nearer to the object-glass, it combines with that to shorten its focus, rendering the image less, and so diminishing the power. In shortening this focus, the rays converge more, and, after crossing, diverge more: this greater divergence will spread them over a larger portion of the eye-glass, and thus contribute to enable that lens to refract them

parallel, but it will not quite do it; they will, therefore, require a still larger area of that lens, and that is only to be obtained by removing it a little further off, by which the rays will take area enough to be refracted parallel. Now, with these facts, we will refer to the annexed diagram.

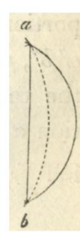
Let *a b* be the curved image produced by the object-



glass, and suppose it to be formed in a field-glass so figured as not in the least to alter it, but merely to have deflected the lateral pencils *c* and *d*, enough to come within the area of the eye-lens *e*, which is placed, with its focus *f*, just touching the image *a b:* it will, therefore, refract the pencil *f* in parallel rays *e g* to enter the eye at *g*, and give distinct vision of the central part of the image *a b;* but it will be seen that the circumference of the lens *e* is too far from the image, and that the curve *h i* is the place to which each part of the eye-lens must be brought in succession, to obtain distinct vision of the different parts of the image; therefore, the whole image cannot be seen distinct at the same time. Now, it is possible to figure the lens *e* so that it shall coincide with the curve *h i*, and thus apparently cure this

evil: but that would induce other greater evils, not necessary to be stated here; so the eye-lens must be a plano, and placed, as here shewn, with its flat side to the eye; and other means must be devised to alter the lateral pencils *c* and *d* without affecting the central pencil *f*. It will be seen that the pencil of rays *d*, in passing the boundary-line *h i*, continues to open wider in its passage to the lens *e*, by which the rays cover too large an area, and are, therefore, refracted in a convergent state towards *g*; but, if the pencil *d* was rendered more divergent, then the lens *e* would refract them parallel. For this purpose, let the field-lens be curved,* by making it a plano or a meniscus, and let its centre remain on the image at *f*, which will then remain unaltered; but the circumference of the field-glass will be so much nearer to the object-glass as to shorten the focus of the lateral rays; thus increasing the curvature of the image to *j k*, and, in so doing, the lateral rays, as above stated, will diverge more; therefore, although they now have to travel two small additional distances to reach the eye-glass, yet they will be refracted by it parallel towards *g*, and so give distinct vision of the circumference, and of all other parts of the image, at the same time with the central portion: thus, one evil is corrected. The correction of the other evil, that of the circumference being magnified more than the centre, follows with it. The curve of the image *a b* was a fault, and we have now increased that fault, by bending the image to *j k*. This apparent increase of fault

* By the curvature of the lens is meant the curvature of the surface, which is equidistant from the two exterior surfaces of the lens. Thus, the dotted line *a b* represents the curvature of the lens in the annexed figure.



affords the second cure; for the pencil of rays, instead of occupying the place of the pencil *c c*, will be moved a little nearer to the axis in the dotted lines *l l*, where the lens *e* will not deflect them quite so much towards the axis. Thus, the circumference of the image is lessened by the means that rendered it distinct, and straight lines will be represented straight in all parts of the field. The curvature of the field-glass that will render the largest field distinct all over, I find to be a meniscus the concave side of which has a long radius; and I use two of these instead of one, because of the well-known law, that the error by figure is four times less with two lenses than with one. If the focal distance of the eye-lens is two, its aperture should be one, and that of the field-lens will be three, and its aperture two; but when two lenses are used, their focal distance may, together, be a little less than three.

The various pencils of light, after passing through the eye-glass *e*, are to be directed upwards into the eye; therefore, a second flat speculum *i* is placed before the eye-glass at an angle of 45°, so as to receive all the pencils just as they meet together, and reflect them upwards into the eye. As the eye is to be put where all the pencils meet, there must be no portion of speculum higher than that little circle of congress; and as a portion of the eye is to be allowed to look over the edge of the speculum, its upper edge is ground as thin as can be done with safety. This completes the optical part of the instrument. If we now look downwards into the eye-speculum, and leave a portion of the eye to look over its edge toward the arrow $a'' b''$, where the drawing-paper is placed, we shall receive the rays from the telescope in exactly the same direction and divergence as those that enter the eye from the paper, and both image and paper will be seen together

distinctly, and will allow that image to be correctly traced on the paper. When drawing with this instrument, the eye can be so placed as to remove any portion of the image from the lower part of the paper: the pencil is best seen in this lower margin, where the image is beginning to disappear. For the sake of room in the engraving, the image $a'' b''$ is placed too near: in proportion to this diagram, that image would be nine inches below the eye-piece, and five times as large as it is drawn, because the extreme parts $a'' b''$ will always be seen in the direction $i\,a''$ and $i\,b''$.

A telescopic image has an advantage over others, in that it can be placed at any required distance from the eye, and thereby be rendered distinct to any sight: and this is an important feature in the graphic telescope; for it allows us to place the paper at the most eligible distance from the eye, and then, by adjusting the telescope, to bring the image to exactly the same distance, when the pencil, or crayon, and the image will both be seen together equally distinct; and then both eyes may be open to see the pencil, though one only sees the image. When the eye-piece is drawn away from the object-glass to the utmost extent compatible with seeing the image of a given object distinctly, the rays from the eye-glass which enter the eye are parallel, and the image appears distant, so we cannot place the paper far enough to see both together; but by pushing in the eye-piece a little, the rays will diverge a little, as though they came from a nearer object; and if we push in the eye-glass as much as we possibly can, consistent with distinct vision, the rays will diverge as from the very nearest object that can be seen distinctly, and the paper would require to be placed as close to the eye as it could possibly be seen distinct. It

is a very small distance that we have to move the eye-piece to produce the extreme effects; therefore, when good vision is obtained, it is easy to adjust the instrument so that the rays shall diverge exactly as much as those which come from the paper. The dotted rays from the arrow $a'' b''$ shew the divergence of those that proceed from the eye-glass against the speculum and into the eye, and thus make the image appear to be at that exact distance. When I wish to make an extremely small copy from a large picture, I do not effect the whole reduction by giving the required distance to the picture, for ordinary rooms do not allow that distance; but I place the picture as far as I can, and do the rest by using spectacles, the focus of which is so short as to let me see the paper when placed so near as to reduce the image to the required size. This diagram represents the instrument in use as a microscope; for the object $a\,b$ is near, and the image $a'' b''$ is larger than it; but the object-speculum c is made to revolve on the axis of the telescope, so, if it is turned a quarter round, it will receive rays horizontally from objects at any distance; then the parallel rays $j j$ $k k$ will represent the pencils of light which proceed from a distant view, and these will include that portion of it which will just fill the field of view, and be represented by the arrow $a'' b''$.

Having now explained the principle on which the instrument acts, I will describe its mechanical construction, by which I have adapted it to the various purposes of drawing. Fig. 2 represents a small graphic telescope, such as will include the diagram, fig. 1, these figures being half the real size; $l\,m$ the tube, containing two inner ones to draw out: at m is a ring-seat for the eye-piece; it is only seen by dotted lines: at the end

of the inner tube is a neck *n*, shewn separate in fig. 3; it is screwed within to receive the cell *o*, which contains the object-glass, and it is screwed on the outside to receive the short tube *p*, which contains the object-speculum *c*. Fig 4 shews this in section: the speculum is lodged in an inner tube *q*; this tube is only confined in the tube *p* by the screw *r*, fig. 2, which also serves as a nib to turn the inner tube round, and so shut up the speculum: *s* is the aperture for the rays to enter: *t* is the eye-piece; one portion is cylindrical, to slide into the tube, and stop against the seat *m*: the outer end *v* is also made cylindrical, and then the top *v* is filed away to admit the eye, and the bottom *u* is filed away to let the eye look through; two grooves are made within the neck, as shewn at *v v* in the front view, fig. 5; these receive the slide *w*, a top and side view of which is shewn in figs. 6 and 7: on this slide, the eye-speculum *i* is cemented with black sealing-wax. Fig. 8 shews the upper edge of the speculum *i*. Fig. 9 is a section of the eye-piece, to shew the three lenses, and how the whole is put together: *x* is a cap that slides on the neck *v* to shut up the eye-end: *y* is a broad cap screwed into the other end when not in use. This eye-piece is made to enter the telescope either end foremost; therefore, when packed up, it lodges in the tube *l m*, fig. 2, in the position shewn in fig. 9, and the cap *y* serves to pull it out by. I have now described a small graphic telescope, the powers of which I vary by changing the object-glass; the shortest object-glass is four inches focus, the next six inches, and the third eight inches focus; these, with this eye-piece, magnify three, four and a half, and six times; for greater powers, longer tubes are used, with ten-inch and twenty-one-inch object-glasses, and a third size made to hold a three-foot object-

glass: with these larger ones I also vary the size of the eye-pieces, the smallest having an eye-lens of one-inch focus, and the largest being made with an eye-lens of two and a half inches focus.

I have three sorts of stands for using these telescopes on. Figs. 10 and 11 are two views of a mahogany stand, by which the telescope may be used on any steady table: it is made to fold up by being jointed at top with a common hinge, and hollowed at each side to receive the telescope; then, to increase the grip round the telescope without using thicker wood, two stubs of wood 1 1 are fixed in on each side, and these have centre-bit holes opposite them, to let the stand shut close when out of use; 2 2 is a wire fitted in with a pin at each end; this fastens the telescope, and makes the whole stiff together (this wire is shewn separate just below); one of the pins takes out to let this wire fall into the groove 3. A pin 4 fixes the leg 5 in its right place; in the latter there is a hole 6 by which the same pin 4 fixes it when shut up, the leg being made to move on the screw 7. This stand is constructed to leave the space on the table under the eye-piece quite clear, and so make room for paper to be laid there. Although this stand is a good one, it confines the use of the telescope to places where a steady table can be had, and with that it cannot easily be used on uneven ground; these and other difficulties I have most effectually overcome by the construction of the table and stand fig. 12, and this I find by long experience completely answers its intended purpose: it may be used on the most uneven ground, is quite steady even in a windy day, is very light, and folds up within three inches of thickness, and, therefore, is very portable. 8 8 is the table, about nineteen inches square; it has three legs, one in front is made of the four square sticks 9 9 9 9,

which spread to the four corners of the table, and one at each side is made of two sticks 10 10 and 11 11. The four sticks of the front leg are jointed together at bottom by four hinges, as shewn in fig. 13, and the mitres carefully made to be close when the sticks are spread out; their upper ends are made fast to the table by four hinges; these, not having to move as hinges, but to act as convenient connexions, are placed in any convenient position; the side-legs are jointed at bottom by one hinge each, also with a close mitre, and at top they are jointed to the table by two hinges each, as close as possible to the four sticks 9 9 9 9. These side-legs being movable, to suit uneven ground, their hinges are carefully placed in line with each other; when these side-legs are spread out wide enough to make the table stand level, or at any convenient slope, they are confined from going further by strings 12 12, which have loops to fit on the point of the legs; they then cross under the table to its opposite sides, where, by loops at their upper ends, they catch on to one of the screws or knobs sticking out for that purpose. Fig. 14 is the under side of the table, to shew the place of the eight hinges: these have their pins driven out, and steel pins with ring-ends are fitted to them; thus the legs are readily attached to or removed from the table, and these legs fold up in eight close sticks. The two legs 13 13 which hold the telescope are hinged together at top, as shewn in figs. 10 and 11 (fig. 12 is a front view of this part); but here two more legs 14 14 are added; these four are hinged to the table with movable pins, as shewn in fig. 15. They hold a short telescope, like fig. 11, sufficiently firm; but when the telescope is a long one, it requires two more sticks 15 15 to be added; these latter are joined by a sliding nut and screw 16, and are each attached at bottom by one

screw to the hinge-flap, which is removable by pins like the others: a string 17 holds them up against the telescope. This upper stand is placed so that the edge of the eye-speculum shall be over the middle of the table, and eighteen inches above it. To direct the telescope to the right or left, I move table and all together, but in difficult ground this is liable to be inconvenient; for such cases the upper stand 13 14 15 should be attached to a separate board, and this made to turn on the table 8 by a central pin; then, if the table is stuck fast in the ground, it will be more completely steady, and a full range of view may be had without disturbing it, but when moved to take in a second or third portion, I clamp the board and table together again, to make the whole quite firm and steady. The position of the two speculums, at an angle of 45° with the axis of the telescope, requires that the telescope should be parallel with the table, and whilst that is the case the table may be level, or put in any convenient slope. When drawing a view from nature, this parallelism must be observed if the horizon crosses the middle of the field of view; but, should the object-speculum be directed much above the horizon, to the top of a tower for instance, the top being further from the telescope than the bottom, would be seen smaller, *i. e.* there would be perpendicular perspective: this is easily corrected; but before doing so, another property must be explained. By considering the diagram, fig. 1, it will be seen that if the paper was put nearer to the eye than the arrow $a'' \ b''$, that image would be exactly so much smaller, and on putting the paper further off, it would be so much larger. This enables us to make large or small sketches with the same instrument, by only altering the distance of the paper; but leaving that for the present, this property will at once shew the

means of correcting any error; for, suppose the image of the top portion of a tower, which should extend from b'' to a'', is so deficient that it extends only to z, let the paper at a'' be lowered to a''', leaving b'' where it is, the eye will then look through z, and see that part of the image extend to a''', where it is restored to its proper dimensions. If the observer was on the top of a high building, and directed the object-speculum downwards, then the same sort of correction must be made at the part b'' instead of a''. The eye-piece, instead of screwing, is made only to slide into the tube, in order to allow it to be turned round to the right or left, and so effect the same kind of correction when the view is much extended to the right or left. The cases where this correction is needed occur very seldom, and then the correction is inversely as the power; for, when the instrument magnifies three times, 1° of slope given to the paper will correct 3° of change in the telescope, and with power of six it will correct 6° of change.

With the two stands now described, this correction is effected by using a drawing-board with four short feet, made by passing a screw through each corner; thus either end may be lowered till the image is rendered correct. But the third stand, fig. 16, is made of brass, and contains in itself the means of effecting this correction. Whilst making a correction, either by moving the paper or the telescope, care must be had to preserve the eye-piece at the right distance from the paper. I have therefore fixed the saddle 18, figs. 2, 16, and 17, to the side of the telescope: this has a dove-tail groove, and the dove-tail slide 19 on which it moves is the segment of a circle, whose centre is at the eye-hole or edge of the speculum; consequently, sliding the telescope up or down does not alter the height

of the eye-speculum, it only alters the inclination of the instrument to the paper, and thereby effects the required correction. The curved slide 19 is, for the sake of portability, attached by a screw 20 and two steady pins to the vertical central pin 21 : this allows it to be turned downward when out of use, and so to pack close to the side of the legs. The pin 21 is that on which the telescope turns right and left; I have, therefore, made it very conical, to give sufficient strength, and yet save all the room, so as to have strong joints for the legs, with good abutments, and yet make them lie close together when shut up: fig. 18 is a section through the crown of the joints, fig. 19 a top view of it, and fig. 20 the top of one leg, to shew the shape of its joint. These legs have each two lengths to pull out, and thus increase the height above the paper; the three feet are double screws, fitting either way; one way they are smooth, the other they are sharp-pointed to stick in a drawing-board, and so keep steady.

Having now described the Graphic Telescope, with its different stands, I shall proceed to shew that it is also a graphic microscope, as far as artists require, but will first describe it in its most complete form.

Fig. 21 is a side view of a graphic microscope, one-fifth the real size; *l m* the tube made to fit the stands, figs. 11 and 12, and to receive the eye-piece *t*, all of which have already been described. This does not pull out, but, by enlarging the tube *l*, the end *m* may be made to slide in it, and this is a very convenient mode of varying the power. *n* is a neck, larger than that in fig. 3, but suited to receive the same object-glasses and the same speculum-tube *p*; on this neck is fitted the rack 22, by means of the clamp, fig. 22 : this rack is a square rod, and on it is fitted the plain stage 23, with a spring 24 to hold the

pinion, similar to that in my vial microscope, described in the first part of this volume: a dark chamber 25 is screwed into the stage; 26 is the mirror, arm, and socket. It is now ready to receive any object for drawing, either transparent or opaque. Any of the well-known lateral movements may be added to this stage when required. This mode of placing the stage is requisite for such objects as must be placed horizontally, and for all that have a right and left side; but, when using high powers, and light is of consequence, I remove the speculum-tube *p*, for the sake of light, and because the stage could not come near enough, and slide the rack 22 into the side-socket 27. Fig. 23 is an end view of this socket: now, the stage, moving in a direct line, may be brought quite close to the object-glass. I have here placed the socket 27 under the tube *l*, but as that will turn round in the stand, the stem or rack 22 may be placed on *either side*, and thus give room to bring a light close behind the object, and by sloping the drawing-table like a desk, the direct daylight may be used. Though the portable table is as good as any for the microscope, there is no real necessity for it; but I like to joint the stand to the drawing-board, quite like the table fig. 12, only without the legs, for then the object, the microscope, and the drawing-board, are all held together in one mass, and thus there is no direct cause for their being disturbed whilst tracing the image.

With a graphic microscope we may trace an image much larger than the stated magnifying power, for ten inches is the distance at which the magnified image is measured, and though we sometimes trace within that distance, yet I usually draw at the distance of eighteen inches, which makes the image four-fifths larger.

Having now described a stationary graphic microscope,

I will shew how the telescope may be used as a microscope: premising that whenever it gives an image larger than the object it is a microscope, and that, though a telescope magnifies most with an object-glass having a long focus, it is the reverse with the microscope; for that magnifies most with a short object-glass, and the further that is placed from the eye-piece the greater will be the power.

The telescope, fig. 2, being suited to receive either a four or an eight-inch object-glass, I put the shortest one in, and pull the tubes out the full length, which is rather more than double the focus; therefore it will require the object to be placed within eight inches distance from the object-glass, to enable it to give an image at the eye-piece. This image will bear exactly the same proportion to the object as their respective distances are from the object-glass; in this case it will be a little larger, and the eye-piece will magnify the image about six times; and if the paper on which the image is traced be more than ten inches distant from the eye-piece, it will be still larger, so that this combination will make a miniature of one inch appear as large as life. I sometimes lay the object on the table or drawing-board, like *a b*, fig. 1, because then the same board will hold all together quite steady, and gradually raise it till its image is given large enough. If the object is placed vertically on either side of the object-speculum, the instrument may be slid on the table to or from it till correct vision is obtained: even here, that all may be held together, I prefer clamping this side-support to the board. In this, as well as in a telescope, the image will be gradually lessened if we gradually increase the distance of the object, and gradually slide in the object-tube to regain distinct vision, so we can always choose the exact size that is most eligible. It is obvious that, by using object-glasses of

shorter focus than those provided for the telescope, we may carry on the power till it equals the stationary microscope.

I will now shew some of the advantages obtained by using this graphic telescope: premising that instruments not being masters, they cannot make artists of those who want the necessary previous knowledge and practice; but my instrument is a most excellent servant, and one that will greatly facilitate the progress of an artist.

In the first place, it sets him quite at liberty in the choice of the distance from which he will take his view, and also in the size of the sketches; for without such help we are frequently obliged to go much too near in order to see the leading features, and thus, by the violence of the perspective, lose much of the grandeur and true proportion. With my telescope there is no distance from which an artist would choose a view, but what it will shew distinctly, and of any size that he could wish. When a back-ground is mountainous, sketching further off brings them up in much grander proportion, and thus the telescope finds numerous fine views that before were unnoticed; intervening objects, hiding them from a near view, and sometimes water removing us too far to see them large enough to claim our attention. In thus drawing attention to more distant views, I do not mean to neglect the grand and imposing effect so often obtained by a near view, where the artist is enabled, by the rapid increase or decrease of the perspective, to alter so much the apparent proportions of the object, as to render it greatly superior to its natural proportions as seen from a distance; but for these, drawing by the eye is frequently better than with any instrument.

This telescope will give all the views strictly correct,

without any care or anxiety about the perspective; it is therefore very valuable for drawing shipping and boats, the various curves of which cannot be known, yet are hereby given quite correct. Trees may be drawn more correctly, and with much more of the details, than otherwise we should have patience to attend to. Indeed, all local objects,—wagons, and the various implements of husbandry, which must be had, and yet are scarcely worth the trouble, animals, figures, and birds,—may readily be drawn; and by taking away the object-speculum, these objects or views may be drawn at once on stone the reverse way, and so be printed the right way: thus we may now publish real sketches from nature.

Wild or savage animals may be sketched from a place of safety, at such a distance as not to rouse or disturb them; also timid animals, which will not remain still if we go near them. In this case a good artist needs not always to trace; the image of the animal may be in one part of the field, and a copy made of it close by the image, which is a peculiar advantage when the object is in motion.

Portraits of any size may be drawn from life. To do this it is convenient to place the head of the sitter in contact with a V-shaped gap in a board, attached to the back of a chair.

The instrument is of great use for copying or reducing from statues or pictures, architecture or machinery. It also supplies with the greatest ease all those magnificent effects produced in mountain scenery by accuracy in geological details.

Artists may also employ mere draughtsmen to sketch correctly the inferior details for them, and thus save their time to attend to the nobler parts of the art. Few flowers

remain in the same state long enough to be drawn correctly, with the lights, shadows and reflections, caused by sunshine: with this instrument that may be done. Also the most minute botanical or entomological specimens may be drawn as large as needful to shew the particular details.

If this telescope, table, and draughtsman, were mounted on a polar axis (a strong axis placed parallel to that of the earth), and moved by a clock, a most perfect map of the stars could be traced, of any required size; for he would then direct his telescope to succeeding portions, as though they were all quite stationary.